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RESEARCH ARTICLE

Genotypes by Environment Interaction Effect and Biplot Analysis (GGE) For Seed Cotton Yield in Some Egyptian Cotton Genotypes (*GossypuimBarbadens* L)

El-Adly, H.H

Cotton Research Institute, Agricultural Research Center, 9 Cairo University Rd, Oula, Giza District, Giz Governorate, Egypt

ABSTRACT: Seed cotton yield is a trait governed by multiple genes that cause changes in the performance of genotypes depending on the cultivation environment; therefore plant breeders always test their genotypes across diverse environments to assess consistency of superior genotypes for wide adaption. Twelve Egyptian cotton genotypes (G) were studied across three various environments (E) representing Middle and Upper Egypt during the three seasons (S) 2016, 2017 and 2018. Genotypes (G) across environments (E) over years (Y) revealed significant differences for seed cotton yield. Significant values of mean squares due to genotypes environment interaction (G × E) and genotypes x year interaction (G × Y) for (SCY K/f).Moreover, the interaction effects due to (Y × E × G) were also significant for seed cotton yield (SCY K/f),indicated that (SCY K/f) of cotton genotypes is mostly affected by environment and years. Environment significance explained by 73.3% (7.2%, 32.3% and 35.9%) for year, environment and their interactions, respectively of the total sum squares due to G, E and (G × E) interaction however partitioning of variance components for environment revealed that both predictable (E) and unpredictable (Y) components were important source of variation. The environment (E), genotype (G) and (G × E) interaction effects explained about 43,9% (32.3%, 4.4% and 7.2%), respectively, of the total sum squares variance components. According to ideal genotype Biplot analysis, genotypes G1, G5 and G7 are more stable and had the high yielding ability compared with the grand mean performance with other genotypes thus genotypes identified as ideal genotypes for seed cotton yield (SCY K/f).

KEYWORDS: Egyptian cotton, genotype, seed cotton, Environment significance.

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1. INTRODUCTION

Egyptian cotton germplasm has narrow genetic base and little variation is available for development of high yielding cotton cultivars. Cotton genotype performance depends on genotype (G), environment (E) components and interactions (GE) between them, however genotype environment (GE) interaction become more important and challenging when ranking of breeding lines change in different environments [1-3].

Genotype environment (GE) interaction complicate the process of selection of genotypes with superior performance, for this reason the Plant breeders evaluate genotypes performance at various environments traits because the interaction components provide basic information related to adaptability of cotton genotypes. Numerous methods have been developed to reveal patterns of Genotype environment (GE) interaction, such as joint regression [4,5].

Stable expression of different attributes of cotton genotypes in different environments is very difficult to attain [6]. GGE Biplot analysis is believed to be very effective in explaining patterns of genotype environment (GE) interaction and usually is the first choice of plant breeders to identify best performing genotypes for targeted environments [7]. The GGE Biplot analysis is the graphical approach to assess genotypes main effects integrated with genotype by environment interaction (GE) for evaluation of genotypes under diverse environments [8].

GGE Biplot has very useful features such as visually assessing the discrimination ability of the genotypes to different environments, relationship among the genotypes and environments and ideal environment and genotype [9].In the current study, cotton genotypes collected from Egyptian cotton breeding program, Cotton Research Institute were used to assess their relative performance of genotypes a cross different environments using GGE Biplot analysis to identify the ideal genotypes which have stable yielding for lint cotton yield in Middle and Upper Egypt regions for future breeding program.

2. MATERIAL AND METHODS

2.1 Materials used

Ten Egyptian cotton genotypes and two cotton cultivars, Table (1) were grown in 2016, 2017 and 2018 seasons at different locations represented Middle and Upper Egypt regions, i.e. Beni–soufe (E1), El-Fayoum (E2) and Sohag (E3).

**Corresponding Author: hassaneladly2015@yahoo.com*

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2.2 *Experimental design*

The experimental design in all locations was randomize complete block design with six replicates. Each experimental plot consisted of five rows, 4m long, 60 cm width and 30 cm between hills within a row. The hills were thinned to two plants. Cultural practices were applied as recommended for growing cotton. The middle three rows of each plot were hand harvested to determine seed cotton yield (SCY K/f).Fifty open bolls were picked from the two outer rows per plot to determine fiber properties, i.e. yarn strength (Y.St unit), fiber uniformity ratio (UR %), Upper half mean length (UHM mm) and Micronaire reading (Mic).

2.3 *Evaluation Tests*

The lint cotton samples were tested at Cotton Technology Laboratory, Cotton Research Institute, ARC. High Volume Instrumentation (HVI) was used for determinations of fiber traits. Seed cotton yield (SCY K/f) data for genotypes under study at different locations was analyzed using analysis of variance to determine the effects of environment (E), genotype (G) and their interaction (GE). Combined analysis of variance was computed for genotypes, locations, seasons and their interaction according to Snedecor and Cochran [10] for each location.GGE Biplot analysis [9] was used to interpret the genotype by environment interaction (GE) using Gen-stat14th ed. [11]. Only variables with significant effects of G and GE were appropriate for analysis using GGE Biplot [12].

3. RESULTS AND DISCUSSIONS

The present investigation included the evaluation of 12 long staple cotton genotypes belong to Egyptian cotton (Gossypium barbadense. L), at different locations representing Middle and Upper Egypt in the three seasons 2016, 2017 and 2018 in order to study genotypes performance and stability under different environments. Mean performance of 12 Egyptian cotton genotypes for seed cotton yield (SCY K/f) showed in Table (2). Genotypes G2, G5, G8 and G9 recorded significant seed cotton yield (SCY K/f) compared with the grand mean performance for all cotton genotypes. On the other hand, the genotypes G1 and G7 gave insignificant higher seed cotton yield.

Combined analysis of variance Table (2), revealed significant mean squares of years (Y), environments (E)and years × environments interactions (Y × E) for seed cotton yield (SCY K/f), possibly due to environmental condition change across various environments over years. Significant values of mean squares due to genotypes (G) and (G × E) interaction and (G ×Y) interaction indicated that differential genotype expression across environments depends on the reaction of genotype on changing environmental conditions across locations and years. The second order interaction (Y ×E×G) were significant for seed cotton yield (SCY K/f), indicated that seed cotton yield of cotton genotypes is mostly affected by environment and years. Significant environmental effects explained about 73.3% (7.2%, 32.3% and 35.9%) for year, environment and their interactions, respectively of the total sum squares due toG, E and (G × E) interaction Table (2), However partitioning of variance components for environment revealed that both predictable (E) and unpredictable (Y) components were important source of variation. The environment (E), genotype (G) and (G × E) interaction effects explained about 43, 9% (32.3%, 4.4% and 7.2%) respectively, of the total sum squares variance components. Significant differences of all source of variation could help cotton breeder for selecting stable genotypes. The present data were in agreement with Killi and Harem [13] and Satish and Chabra [14].

Campbell et al. [15] and Gul et al [16] reported that effect of genotypes × environments interaction (G × E) was significant for seed cotton yield. These results indicated that the cotton crop as well as other crop varieties showed differential responses when grown under different locations and years.

Seed cotton yield (SCY K\f) and stability of 12 Egyptian cotton genotypes were assessed from the coordination of the middle environment (CAE), (Fig.1). Genotypes on the extreme right on the CAE ordinate axis indicate a relatively stable. Stability of these genotypes depends on their distance from AE abscissa. Genotypes G1, G3, G5 and G7 were the best stable genotypes compared with other genotypes. On the other hand, the genotypes G2, G4, G6 and G8 showed the absolute length of the projection of a genotype stable. On contrast the genotypes G11was the most unstable genotype. From above results it could be concluded that the genotypes G1, G5 and G7 are stable and had the high yielding ability compared with the grand mean performance and be incorporated as breeding materials in future of breeding program to produce stable and high yielding cultivars. These results are in agreement with those obtained by Farias et al [17], Saide [18], Baker [19] and Imtiaz et al [20], The ideal genotype can be used as a benchmark for selection, genotypes that are far away from the ideal genotype can be rejected in early breeding cycles, while genotypes that are lose to it can be considered in further test [21]. An ideal genotype should have a mean seed cotton yield (SCY) that is consistently high over all environments of interest. This ideal genotype is graphically defined by the longest vector in PC1 and PC2 without projections, and represented by arrow in center of concentric circles [22]. Although this genotype is more of a representative model, it is used a reference for assessing genotypes. Thus, the genotypes G2 and G5 which fell into the center of concentric circles were ideal genotypesin terms of higher yield ability and stability, compared with the genotype with the rest genotypes. In addition, genotype G1 and genotypes G8 and G3 located on the second and third concentric circles, respectively, are closest ideal in terms of high seed cotton yield and phenotypic stability (Fig. 2).

Table 1 Code and pedigree of 24 cotton genotypes, their parents and their origins

Code	Genotypes
G1	[(G91 × G90)] ×G85
G2	[(G91 × G90)] × [G83 × (G75 × 5844)]
G3	[(G91 × G90)] × [(G85 × G83)]
G4	[(G91 × G90)] × [(G83 × G80) × G89]
G5	[(G90 × Aust)] × [G83 × (G75 × 5844)]
G6	[(G91 × G90)] × Karshink
G7	[(G83 × G80) × Dandara] × [(G90 × Aust)]
G8	[(G91 × G90)] × G80
G9	(Giza 90 × CB 58)
G10	[(G83 × G80) × G89] ×Aust
G11	Giza 95
G12	Giza 90

Table 2 Mean performance of 12 Egyptian cotton genotypes for seed cotton yield (SCY K/f) for three seasons at three locations

Code	Genotypes	2016	2017	2018	G (mean)
G1	[(G91 × G90)] ×G85	10.21	11.27	9.09	10.19
G2	[(G91 × G90)] × [G83 × (G75 × 5844)]	10.06	11.41	9.46	10.31
G3	[(G91 × G90)] × [(G85 × G83)]	9.80	10.53	9.28	9.87
G4	[(G91 × G90)] × [(G83 × G80) × G89]	10.31	10.97	8.67	9.98
G5	[(G90 × Aust)] × [G83 × (G75 × 5844)]	10.33	11.34	9.66	10.44
G6	[(G91 × G90)] × Karshink	10.19	10.30	9.20	9.90
G7	[(G83 × G80) × Dandara] × [(G90 × Aust)]	10.86	10.25	9.49	10.20
G8	[(G91 × G90)] × G80	10.44	11.49	9.37	10.43
G9	(Giza 90 × CB 58)	10.64	11.48	9.24	10.45
G10	[(G83 × G80) × G89] ×Aust	10.69	9.72	8.61	9.67
G11	Giza 95	10.21	8.69	9.72	9.54
G12	Giza 90	9.28	9.89	7.91	9.03
Grand means		**10.25**	**10.61**	**9.14**	**10.00**
LSD 0.05		**0.31**	**0.21**	**0.21**	**0.27**

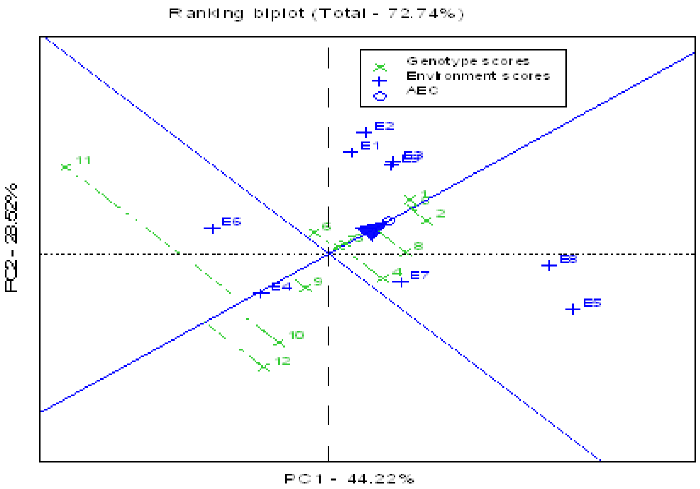

Figure 1 The" Mean vs. Stability" view of the GGE Biplot ranking for seed cotton yield of 12 genotypes across 3 environments in Middle and Upper Egypt over three seasons.

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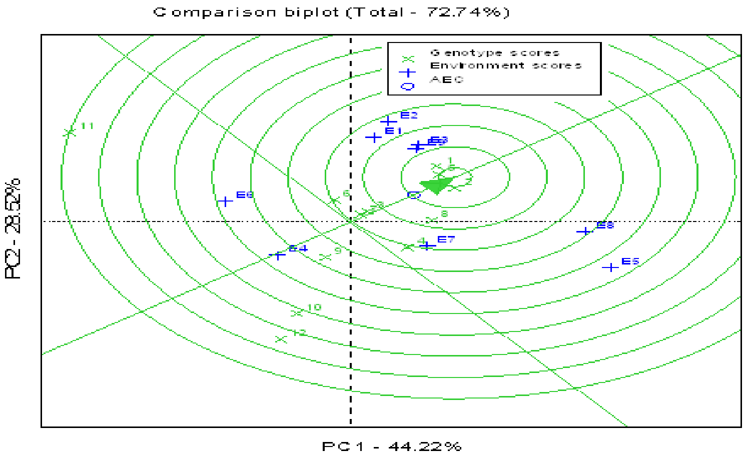

Figure 2 Classification of the genotypes from the GGE Biplot of seed cotton yield (SCY) in different environments

The genotypesG9, G10, G11 and G12 were undesirable genotypes because they were at distant from the first concentric circle. Baker (2017) using Biplot analysis of phenotypic stability in some Egyptian cotton genotypes and they found that the genotype G8 {(G91× G90) ×[(G80 × G83) × Dendera]} was ideal genotype and had high cotton productivity and phenotypic stability. Ideal environment for seed cotton yield (SCY) and stability of the genotype has been shown in Fig (3).

The environment located in the first concentric circle in Biplot termed as ideal environment and environments located close to the ideal present study, E3(Sohage 2016) and E9 (Sohage 2018) are located in first concentric circle followed by E1 (Bani-Souf 2016) and E2 (El-Fayuom 2016) environments which are close to the ideal environments as desirable environments (Fig 3); therefore, it should be regarded as the most suitable to select widely adapted genotypes.

The Biplot analysis shown in Figure (4) represent that the corner genotypes that are the most responsive ones can be visually determined. These corner genotypes were G1, G5, G2, G4, G8, G11 and G12. In this figure, locations are divided into six rays divide the Biplot into sectors. The first sector contains four environments, E1, E2, E3 and E9 with Genotypes G1, G5 and G2 as the most favorable. The second sector represents E8 and E5 with the genotype G8 and G4 as the most favorable. The two other corner genotypes G11 and G12 were the poorest yielding (Fig.4).They were located far away from all of test locations, reflecting the fact that they yielded poorly at each environment. The genotypes within the polygon nearer to plot origin (for example G3 and G7 for E1, E2, E3 and E9) are less responsive than vertex genotypes [23]. Figure (5) represents the evaluation and relationship among different environments over three seasons. Environments having vector smaller angles are closely related. Positive correlations were found between E1 (Bani-Souif 2016), E2 (El-Fayuom 2016) and E3 (Sohage 2018) in a location as angle between them. On the other hand the genotypes groups G1, G2, G3, G5, G7 and G8 with the environments E3, E9 and E8 are close to each other in graph area represent the specific adaptation of genotypes to the environments and specific interactions were observed between them. The results indicated that the environment effect is minimal in the variation of seed cotton yield.

Mean performance of the fiber quality for all cotton genotypes under different environments over seasons are presented in Table (4). Micronaire values (Mic) of all genotypes was ranged from 3.9 to 4.1 units with general mean of 4.0 units. The highest value for (Mic) was recorded by the genotypes G1, G3, G4, G8 and G9 which was (4.1 units). Lowest (Mic) value was recorded by the genotype G12 (3.9 units). The genotypes G5 and G2 recorded highest and lowest Upper half mean length (UHM), it was (30.9 and 29.2 mm), respectively. With respect to uniformity ratio (UR %) of 12 genotypes Table (4), ranged from 83.1 to 84.2% of the genotypes G1, G6,G7, G10, G11 and G12 exceeded the genotypes general means. General mean performance of maturity ratio for the genotypes was 0.92, on the other hand the highest and lowest value for maturity ratio was recorded in genotypes G1 (0.94),G5 (0.91) and G11 (0.91), respectively.

Fiber strength (F.St gm/tex) Table (4), revealed that fiber strength (gm/tex) for the genotypes ranged from (36.5 to 38.0 gm/tex). The highest value and lowest value of fiber strength was recorded for the genotypes G3 and G7, it was (39.0 and 36.5 gm/tex).Yarn strength (Y.St) trait exhibited wide variation which ranged from (1840 to 1940) for the genotypes G7 and G11, respectively. The same genotypes recorded the highest and lowest values of yarn strength.

It's clear that the fiber quality of all cotton genotypes under study had a suitable fiber quality for Egyptian long staple cotton which grown in Middle and Upper Egypt Table (6).

Table 3 Analysis of variance for seed cotton yield (SCY) trait across different environments

SOV	df	SS	MS	GE%
R	5	1707695.142	341539.028	
Y	2	9869070.559	4934535.279**	7.2
E	2	44324540.32	22162270.16**	32.3
Y x E	4	49347043.28	12336760.82**	35.9
G	11	6417546.92	583413.356**	4.4
Y x G	22	5923804.293	269263.832*	4.3
E x G	22	9937044.978	451683.863**	7.2
Y x E x G	44	11570455.75	262964.903*	8.4
Er	535	69081958.53	129125.156	

Table 4 Means of fiber quality of 12 Egyptian cotton genotypes at three environments over seasons

Code	Genotypes	Mic	UHM (mm)	UR %	Mature	F.St(gm/ tex)	Y.St
G1	[(G91 × G90)] ×G85	4.1	29.9	84.1	0.94	37.8	1900
G2	[(G91 × G90)] × [G83 × (G75 × 5844)]	4.0	29.2	83.8	0.92	36.8	1915
G3	[(G91 × G90)] × [(G85 × G83)]	4.1	30.2	83.2	0.92	38.0	1905
G4	[(G91 × G90)] × [(G83 × G80) × G89]	4.1	30.3	83.3	0.93	37.4	1905
G5	[(G90 × Aust)] × [G83 × (G75 × 5844)]	4.0	30.9	83.5	0.91	37.7	1890
G6	[(G91 × G90)] × Karshink	4.0	30.6	84.1	0.92	37.1	1850
G7	[(G83 × G80)×Dandara]×[(G90 × Aust)]	4.0	30.0	84.2	0.92	36.5	1840
G8	[(G91 × G90)] × G80	4.1	30.4	83.8	0.93	37.6	1915
G9	(Giza 90 × CB 58)	4.1	29.9	83.1	0.93	36.5	1895
G10	[(G83 × G80) × G89] ×Aust	4.0	29.7	84.0	0.92	37.1	1870
G11	Giza 95	4.0	30.2	84.1	0.91	36.9	1940
G12	Giza 90	3.9	30.0	84.2	0.92	36.7	1915
	Means	4.0	30.1	83.8	0.92	37.2	1895

Table 5 Fiber quality means of 12 Egyptian cotton genotypes in three seasons at three locations

2016							
Code	**Genotypes**	**Mic**	**UHM**	**UR %**	**Mature**	**F.St(g m/tex)**	**Y.St**
G1	[(G91 × G90)] ×G85	4.0	30.0	84.8	0.94	37.2	2060
G2	[(G91 × G90)] × [G83 × (G75 × 5844)]	3.8	28.7	83.4	0.93	36.1	1980
G3	[(G91 × G90)] × [(G85 × G83)]	3.8	29.9	82.5	0.91	38.0	2050
G4	[(G91 × G90)] × [(G83 × G80) × G89]	3.8	30.0	83.3	0.92	36.9	2070
G5	[(G90 × Aust)] × [G83 × (G75 × 5844)]	4.0	30.5	82.9	0.92	36.5	2040
G6	[(G91 × G90)] × Karshink	3.8	30.8	84.3	0.92	36.4	1900
G7	[(G83×G80) × Dandara] × [(G90×Aust)]	3.8	30.1	85.1	0.91	35.9	1920
G8	[(G91 × G90)] × G80	4.0	30.4	84.1	0.93	37.2	2125
G9	(Giza 90 × CB 58)	3.9	29.8	83.3	0.92	36.2	2035
G10	[(G83 × G80) × G89] ×Aust	3.8	30.0	84.1	0.90	36.1	2055
G11	Giza 95	3.9	30.5	84.9	0.92	36.9	2035
G12	Giza 90	3.8	30.0	84.2	0.92	35.1	2045
Means		**3.9**	**30.1**	**83.9**	**0.92**	**36.5**	**2025**
2017							
G1	[(G91 × G90)] ×G85	4.1	29.1	83.4	0.93	37.0	1695
G2	[(G91 × G90)] × [G83 × (G75 × 5844)]	4.1	28.6	83.8	0.92	35.8	1855
G3	[(G91 × G90)] × [(G85 × G83)]	4.1	29.9	82.6	0.93	37.3	1775
G4	[(G91 × G90)] × [(G83 × G80) × G89]	4.0	29.8	82.1	0.92	35.7	1800
G5	[(G90 × Aust)] × [G83 × (G75 × 5844)]	3.9	31.2	83.3	0.90	37.3	1785
G6	[(G91 × G90)] × Karshink	4.1	30.1	83.7	0.94	35.8	1745

G7	[(G83×G80) × Dandara] × [(G90×Aust)]	3.9	29.2	83.5	0.90	35.0	1760
G8	[(G91 × G90)] × G80	4.0	30.4	83.0	0.92	36.5	1780
G9	(Giza 90 × CB 58)	4.0	28.9	83.0	0.92	35.8	1785
G10	[(G83 × G80) × G89] ×Aust	4.1	28.1	83.8	0.92	36.3	1695
G11	Giza 95	3.9	29.4	83.2	0.90	35.2	1935
G12	Giza 90	4.0	29.4	84.2	0.91	36.2	1820
Means		**4.0**	**29.5**	**83.3**	**0.92**	**36.2**	**1785**
2018							
G1	[(G91 × G90)] ×G85	4.3	30.5	84.2	0.94	39.1	1947
G2	[(G91 × G90)] × [G83 × (G75 × 5844)]	4.2	30.4	84.2	0.92	38.5	1907
G3	[(G91 × G90)] × [(G85 × G83)]	4.3	30.9	84.4	0.92	38.6	1893
G4	[(G91 × G90)] × [(G83 × G80) × G89]	4.4	31.1	84.5	0.95	39.6	1840
G5	[(G90 × Aust)] × [G83 × (G75 × 5844)]	4.2	31.0	84.4	0.92	39.3	1847
G6	[(G91 × G90)] × Karshink	4.2	31.0	84.2	0.91	39.2	1900
G7	[(G83×G80) × Dandara] × [(G90×Aust)]	4.3	30.6	84.1	0.95	38.7	1833
G8	[(G91 × G90)] × G80	4.3	30.5	84.4	0.94	39.0	1847
G9	(Giza 90 × CB 58)	4.4	31.0	82.9	0.96	37.5	1860
G10	[(G83 × G80) × G89] ×Aust	4.2	31.1	84.2	0.93	39.0	1860
G11	Giza 95	4.2	30.6	84.1	0.91	38.7	1847
G12	Giza 90	4.0	30.5	84.1	0.94	38.7	1873
Means		**4.3**	**30.8**	**84.1**	**0.93**	**38.8**	**2940**

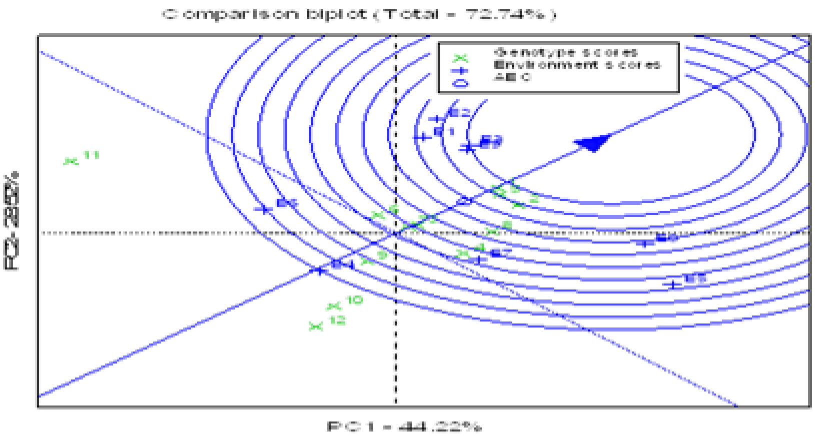

Figure 3. Ideal environment for seed cotton yield (SCY) and stability of the genotype

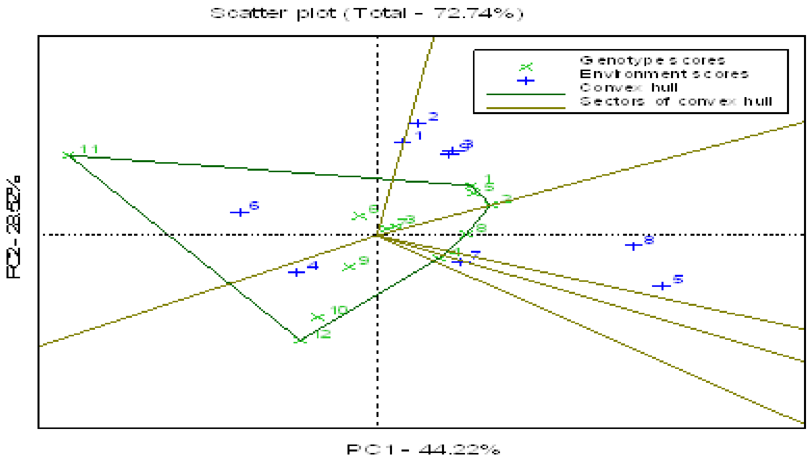

Figure 4. GGE Biplot identification of winning genotypes and their related mega-environment

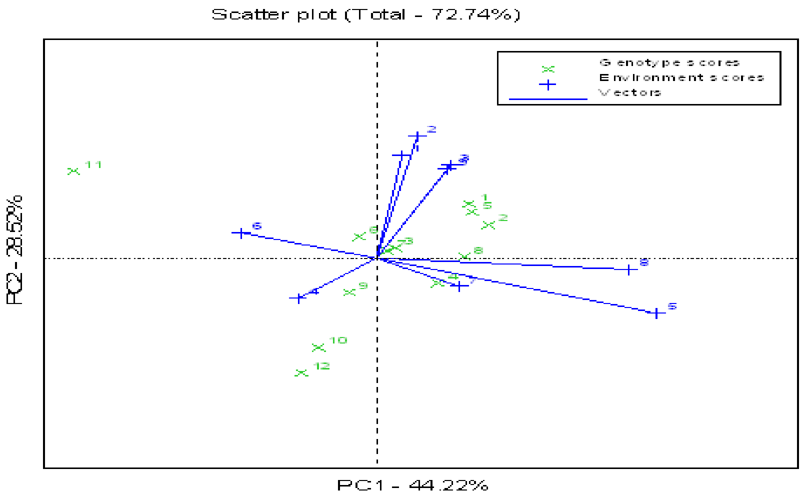

Figure 5 GGE Biplot for the evaluation of the relationship among nine environments

4. CONCLUSION

Based on genotype environment interaction and GGE Biplot analysis, the genotypes G1 [(G91 × G90)] ×G85, G5 [(G90 × Aust)] × [G83 × (G75 × 5844)] and G7 [(G83×G80) × Dandara] × [(G90×Aust)] were declared as best performers and ideal genotypes with respect to stability and producing maximum seed cotton yield in all environments. Therefore, the genotypesG1, G5 and G7 it could be used in breeding programs as promising material in future of breeding program to produce stable and high yielding cultivars.

REFERENCES

[1]. Baker, H.C., Leon, J. 1988. Stability analysis in plant breeding. Plant Breed., 101: 11-23.

[2]. Ali, I.;Khan, N. U.;Mohammad, F.; Iqbal,Abbas Farhatullah, M. A.;Bibi, A.;Bibi, Z.;Ali, S.;Khalil, I. A., Ahmad, S. and Ur Rahman, M. 2017. Genotype by environment and GGE-biplot analysis for seed cotton yield in Upland cotton. Pak. J. Bot., 49: 2273-2283.

[3]. A.S.T.M. 1986. American society for testing materials, D-4605. U.S.A.

[4]. Eberhart, S.A. and Russell ,W.A. 1966. Stability parameters for comparing varieties. Crop.Sci. 9: 36-40.

[5]. Perkins. J. M. and Jinks, J. L. 1968. Environmental and genotype-environmental interactions and physical measures of the environment. Heredity 25: 29-40.

[6]. Kerby. T. A.; Burgess, J.; Bates, M.; Albers, D. and Lege ,K. 2000. Partitioning variety and environmental contribution to variation in yield, plant growth and fiber quality. Proceed. Beltwide cotton conferences, San Antonio, USA, Jam 4-8, 1: 528-532.

[7]. Yan, W.; Kang, M. S.; Woods, S. and Cornelius,P. L. 2007. GGE biplot vs. AMMI analysis of genotype-by environment data. Crop Sci. 47: 643-655.

[8]. Yan, W. and Holland, J. B. 2010. A heritability-adjusted GGE biplot for test environment evaluation. Euphytica, 171: 355-369.

[9]. Yan, W. 2001. GGE biplot–A windows application for graphical analysis of multi-environment trial data and other types of two-way data. Agron. J. 93: 1111-1118.

[10]. Snedecor, G.W. and Cochran, W.G. 1982. Statistical methods. The Iowa State Univ. Press. Ames. Iowa, USA.8 th Ed.

[11]. GenStat 2011. Genstat Procedure Library Release PL22.1. 14th Edition, VSN International Ltd., Hemel Hempstead.

[12]. Blanche, S.B.; Myers, G.O.; Zumba, J.Z.; Caldwell, D. and Hayes, J. 2006. Stability comparisons between conventional and near-isogenic transgenic cotton cultivars. J. Cotton Sci. 10: 17–28.

[13]. Killi, F. and Harem, E. 2006. Genotype × environment interaction and stability analysis of cotton yield in Aegean region of Turkey. Journal of Environmental Biology. 27(2): 427-430.

[14]. Satish, Y.; Jain, P.P. and Chabra, B.S. (2009). Stability analysis for yield and its component traits in American cotton (Gossypium hirsutum, L.). J. Cotton Res. Dev., 23(2): 175-182.

[15]. Campbell, B.T; Chee, P. W.; Lubbers, E.; Bowman, D. T.; Meredith, W. R.; Johnson, J.; Fraser, D.; Bridges, W. and Jones, D. C. 2012. Dissecting genotypes × environment interactions and trait correlations present in the peedee cotton germplasm collection following seventy years of plant breeding. Crop Sci 52 (2):690-699.

[16]. Gul, S.; Khan, N.U., Gul, R.; Baloch, M.; Latif, A. and Khan, I.A. 2016. Genotype by environment and phenotypic adaptability studies for yield and fiber variables in Upland cotton. J, Anim. Plant Sci., 26(3): 776-786.

[17]. Farias F.J.C.; Carvalho, L.P.; Silva Filho, J.L. and Teodoro P.E. 2016. Biplot analysis of phenotypic stability in upland cotton genotypes in Mato Grosso. Genetics and Molecular Research, 15 (2): 1-10.

[18]. Said, S.R.N. 2016. Stability of yield and yield components for some Egyptian cotton

genotypes. Egypt. J. Plant Breed. 20 (3): 541-552.

[19]. Baker, Kh. M. A 2017. Graphical analysis of multi-environment yield trials using Biplot method to study performance stability for some Egyptian cotton genotypes. Egypt. J. Plant Breed. 21(2):245 – 260 (2017)

[20]. Imtiza. A; Khan, N. U.; Mohammad, F.; M. Iqbal, A.; Abbas, A.; Tullah, F.; Bibi, Z.; Ali, S; Khalil, I. A.; Ahmad, S. and Rahman, M. U. 2017. Genotype, by environment and GGE-Biplot analysis for seed cotton yield in Upland cotton. Pak. J. Bot., 49 (6): 2273-2283, 2017

[21]. Yang, R. C.; Crossa J; Cornelius P L; Burgueño J. 2009. Biplot analysis of genotype × environment interaction: proceed with caution. Crop Science, 49, 1564-1576.

[22]. Yan, W K; Rajcan I. 2002. Biplot analysis of test Sites and trait relations of soybean in Ontario. Crop Science, 42, 11-20.

[23]. Yan, W.; Hant, L.A.; Qingbai, S. and Szalvincs, Z. 2000. Cultivar Evaluation and Mega environment Investigation Based on the GGE Biplot. Crop Sci. 40: 597-605.

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